Accumulated stock of knowledge and current search practices: The impact on patent quality

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ABSTRACT

The paper suggests a multidimensional patent-based framework that investigates the relationships among accumulated stock of knowledge, current technological strategies, knowledge search practices and quality of innovation output. More specifically, the work intends to examine how the previous open innovation adoption, the recourse to specific technological strategies, the use of external sources of inspiration and the engagement of external actors for knowledge search affect both the market and the technological value of patented inventions. The methodology is applied to 25,583 patents filed by 68 R&D intense bio-pharmaceutical and technology hardware & equipment companies. Results show that focalization leads to technological acknowledgement and is stimulated by the use of non-patent references as sources of inspiration and the engagement of external scientific actors. In general, the use of patent and non-patent references is positively related to the quality of innovation output. Moreover, when companies have largely employed open innovation to accumulate knowledge, they continue to adopt similar practices in current R&D efforts.

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1. Introduction

The capability of accurately managing knowledge is a strategic asset in R&D intense sectors, where actors recombine and integrate information and expertise belonging to a wide range of technical fields and dynamically expand their stock of knowledge over time (Miller, 2004). Knowledge search (KS) is the part of the R&D process through which firms search for new solutions and technological ideas, solving problems by combining knowledge elements with the aim of creating new products (Katila, 2002). Companies can adopt different search strategies for the development of new technologies and not only employ their internal know-how, but also capture knowledge spillovers from third parties. Even though firms' innovation capability depends on their existing stock of knowledge, companies also employ external sources in order to access new knowledge. Firms can rely either on sources of inspiration and information - such as non-patent references and patent documents - or on external actors to be involved in the R&D process, such as industrial and scientific partners.

A central issue in knowledge management studies is the effect of KS strategies on innovation performance. Firms accurately select the KS practice that may improve the output of the R&D process (Xie et al., 2016). Indeed, many scholars suggested that both the existing stock of knowledge and the current search strategies affect the quality of innovation output and innovation performance (Ferreras-Méndez et al., 2015; Hwang and Lee, 2010; Laursen and Salter, 2006; Wu et al., 2014), positively contributing to the companies' future financial returns and, then, to their market value (Hall et al., 2005).

Firms' professional background, expertise, prior knowledge and experience within specific technical areas inspire future R&D efforts (Arts, 2012; Callaert et al., 2014; Hung and Tang, 2008). Path dependence theory suggests that previous R&D efforts address the future ones. Older and already established knowledge is valuable and companies should learn from distant times (Katila, 2002; Katila and Ahuja, 2002).

Nevertheless, to our knowledge, no scientific contribution regarding the direct dependence of current KS activities from previous search strategies is available. In addition, prior research concentrated its attention on the study of KS from a one-dimensional perspective, e.g. by considering only the nature of the sources employed, the actors engaged, the interaction mechanisms, the organizational practices or the managerial practices.

In this work, we aim at contributing to the current literature by providing a multidimensional patent-based framework that investigates the impact of KS strategies on innovation performance. In particular, we intend to understand how knowledge accumulation addresses current search strategies and how they jointly affect the results of the innovation process.

Since innovation is a complex topic, we aim at investigating such dimensions from a multidimensional perspective, by considering *where* and *how* to search for knowledge and information, *how much* effort

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has been focalized on specific technical areas, *who* is involved in the search process and *how* previous experience affects the efforts under investigation.

A further contribution regards our operationalization, since we studied KS exclusively employing patent statistics. Hence, the suggested framework has been built exploiting information deriving from a valuable source, publicly available, containing objective and standardized data, and widely acknowledged by scientific literature (Belderbos et al., 2010; Burhan et al., 2016; Griliches, 1990; Grupp, 1992; Johnstone et al., 2012).

2. Research questions

This work aims at answering three research questions (Fig. 1):

RQ1: how accumulated stock of knowledge is related to current technological strategies;

RQ2: how stock of knowledge and technological strategies are related to current search practices;

RQ3: how stock of knowledge, technological strategies and search practices are related to quality of innovation output.

The **stock of knowledge** summarizes the professional background and experience accumulated by the firm and potentially available as a starting point for future R&D efforts. It is described by the open innovation (OI) practices previously adopted to achieve experience. This dimension answers the question on *how* to accumulate knowledge: actually, OI strategies delineate the different modalities through which knowledge is developed, transferred and absorbed for future applications.

The **technological strategies** carried out by companies answer the question on *where* to search, with exploitation vs. exploration reflecting local vs. distant KS. Furthermore, the degree of focalization of R&D activities on specific technical fields defines *how much* effort has been devoted to them.

The **search practices** refer to opportunities and sources that firms directly employ in the specific R&D effort under investigation. They are defined by both the sources of information stimulating new developments and the external actors directly engaged in the KS. This dimension answers the questions on *how* to search - i.e. starting from which sources of inspiration - and *who* is involved in the search process.

The **quality of innovation output** is characterized in terms of:

• marketability, as the ability of the patented invention to reach the market and contribute to firm's competitive advantage;
• originality of the technological combination, suggesting the focal firm's capability to generate new architectures and recombine knowledge;
• technological acknowledgement, signaling the technical value of the patented invention recognized by third parties;
• internal value, as a proxy of the private value attributed to the patented technology by its assignee.

3. Literature review

In what follows literature contributions on the building blocks of out framework are reviewed.

3.1. Accumulated stock of knowledge

The OI paradigm (Chesbrough, 2003) has found audience among scholars, business people and policy makers who identify new opportunities to innovate in the access to external sources of knowledge and technology. In contrast to the closed model - which is only focused on internal R&D activities to achieve competitive advantage - OI searches and employs external sources to improve profits (Chesbrough et al., 2006; Garriga et al., 2013; Reed et al., 2012). Indeed, Chesbrough (2006) defines OI as "*the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively*". The effects of OI on firms' stock of knowledge were widely investigated by scientific literature (Belderbos et al., 2004; Perez et al., 2013; Prahalad and Ramaswamy, 2004).

In a **closed system**, new products and services are entirely developed within the boundaries of the innovating firm and directly exploited to enter the market first and win (Chandler, 1990). Yet, even though firms rely on closed strategies, they still need to access to external information and be capable to assimilate, absorb, assess and use new knowledge (Cohen and Levinthal, 1990). For instance, companies can geographically decentralize their R&D efforts and involve their subsidiaries in the search for new solutions and technological ideas (Lahiri, 2010), distributing their R&D activities to share and allocate specific technical fields (Nayyar and Kazanjian, 1993; Nerkar and Roberts, 2004). Further, additional inputs comprise new knowledge externally sourced by both local and distant units. For instance, firms' members may attend conferences and fairs, browse patents, read trade journals or reverse-engineer competing products. Otherwise, companies may hire new skilled personnel to acquire their competencies in specific technical areas. Therefore, even though firms perform R&D internally, they may require external sources of information to stimulate it (Dzikovski, 2015; Gomes et al., 2011; Mothe and Nguyen-Thi, 2013).

When a company decides to adopt OI, many business models can be outlined (Michelino et al., 2015a). This work considers four OI practices for accessing external knowledge: outsourcing of R&D activities, joint development, purchase of external technology and incorporation of knowledge through mergers and acquisitions (M&As). In all these practices it is possible to detect a formal use of external knowledge (i.e. source of innovation), since a third party directly contributes to the R&D effort necessary to develop new solutions and technologies.

In **R&D outsourcing** there is an evident one-way transfer of knowledge from the external partner to the focal firm (Teirlinck and Spithoven, 2008). The outsourcer organization hires the services of an external actor in order to gain access to outer knowledge and information (Ebersberger et al., 2012; van de Vrande et al., 2009). In this way, it absorbs available and specialized knowledge (Foss et al., 2013;
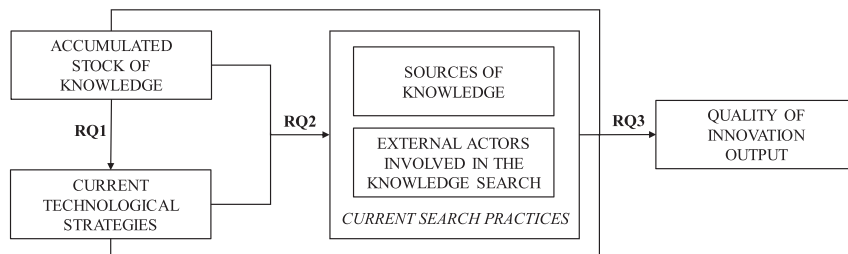
Fig. 1. Theoretical framework and research questions.